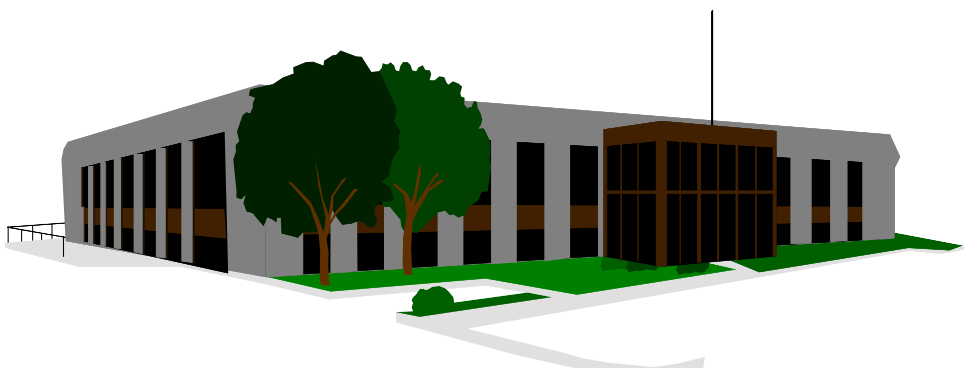
INDOOR AIR QUALITY ASSESSMENT

Granville Village School
409 Main Street
Southwick/Tolland Regional School District
Granville, Massachusetts



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Bureau of Environmental Health Assessment
July, 2000

Background/Introduction

At the request of Paul Petit, Business Manager of the Southwick/Tolland Regional School District, an indoor air quality assessment was done at the Granville Village School, 401 Main Street, Granville, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA). On March 31, 2000, Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA made a visit to this school, to conduct an indoor air quality assessment.

The school consists of three single story wings. The original building is a wood and brick structure built in 1934. A small brick classroom wing was added to the east wall of the original building in 1964. In 1989, the building underwent a complete renovation, which added a new boiler, ventilation system, the cafeteria, gymnasium and rear wing. The original building contains pre-kindergarten, kindergarten, 1st grade and the library media center. The 1964 wing contains the art room, classrooms and offices. The back wing contains classrooms, science classroom, music room the gymnasium and cafeteria. Beneath the classrooms of the 1989 wing is a large storage space. Classroom windows are openable.

Methods

Air tests for carbon dioxide were taken with the Telaire, Carbon Dioxide Monitor and tests for temperature and relative humidity were taken with the Mannix, TH Pen PTH8708 Thermo-Hygrometer.

Results

The school has a student population of 260 and a staff of approximately 45. Tests were taken under normal operating conditions. Test results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in all classrooms surveyed except the art room, which is indicative of an overall ventilation problem in this school. Please note that the art room windows were open, which can greatly reduce carbon dioxide levels in the room.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Figure 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. In order for univents to provide fresh air as designed, they must be unblocked and remain free of obstructions. Importantly, these units must be activated and allowed to operate. Univents were functioning in the majority of classrooms examined, however several univents were deactivated. Obstructions to airflow such as paper, boxes, shelves and other obstructions (see Pictures 1-2) were seen in a number of classrooms.

In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 % would be sufficient to reduce airborne particulates (MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced through increased resistance. Prior to any increase of filtration, each piece of air-handling equipment should be evaluated by a ventilation engineer as to whether it can maintain function with more efficient filters.

The fresh air intake for the kindergarten classroom was sealed with plywood (see Picture 3). As reported by school officials, the fresh air intake was sealed because the univent's heating coil was prone to freezing in cold weather. Northwest winter winds can force cold air into this univent interior, freezing the coil. Therefore, this univent does not have a functioning fresh air intake.

No functioning mechanical exhaust ventilation exists in the 1934 building. Exhaust ventilation in the 1934 building consists of a series of gravity feed wall vents (see Picture 4). These vents were sealed at the classroom level with plywood (see Picture 5). No airflow was detected from these vents. Each classroom is constructed around a ventilation airshaft that terminates in the roof in cupola-like structures (see Picture 6). Above each vent of a classroom is a radiator-like heating element. The heating element heats air, which rises and exits the building through the rooftop vents. As the heated air rises up the vent shaft, classroom air is drawn into the vent.

Exhaust ventilation in the remainder of classrooms is provided by wall or ceiling mounted exhaust vents connected to mechanical fans by ductwork. The location of exhaust vents can also limit exhaust efficiency when the classroom hallway door is open (see Picture 7). When a classroom door is open, exhaust vents will tend to draw air from both the hallway and the classroom. The open hallway door reduces the effectiveness of the exhaust vent to remove common environmental pollutants from classrooms. Without removal by the exhaust ventilation, normally occurring indoor pollutants can build up in classrooms.

The exhaust vents in the 1964 wing appeared to be deactivated. The exhaust vent fan for this wing was found deactivated and had a bird's nest inside the casing (see Picture 8). Exhaust ventilation in the remainder of classrooms was operating.

Of note is the configuration of the media center/library ventilation system (see Figure 2). It appears the sole source of fresh air for this room is a single univent that was blocked by a poster board (see Picture 1). The sole exhaust vent for this area is a wall-mounted grille located above the univent. The placement of the univent and exhaust vent appears to supply fresh air to only half of the room. The univent is straddled by bookshelves, which limit the draw of air to the south half of the room. The exhaust vent in close proximity to the univent tends to draw air from the south section of the room. This configuration creates a dead spot of little or no airflow in the area around the north section of the room. This area is used as a computer lab and contains 30 computers (see Figure 2). With a lack of airflow, heat from computers in this area can build up.

The art room does not have a mechanical fresh air supply. The counselor's room next to the art room does not have an exhaust vent. These areas were originally a single room, which was subdivided by an interior wall, separating the fresh air supply from the exhaust system.

The carbon dioxide measurements taken during the assessment would indicate that the univents are not providing an adequate amount of fresh air even though this equipment is relatively new and in good repair. As reported by school officials, the 1989 renovation project ran short of funds toward the end of the project. Different activities were completed by individuals other than the project contractors. It is possible that the ventilation system in the 1989 wing was not balanced at the end of the renovations. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm) (OSHA, 1997). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings ranged from 71° F to 75° F which were within the recommended range. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Of note was the presence of duel thermostats in some classrooms (see Picture 9). It could not be determined which thermostat controlled the operation of the univent heat. It should be determined which thermostat controls the operation of the univent. The other thermostat should be removed.

The relative humidity in the building was below the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from 15 to 22 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Moisture/Microbial Concerns

The media center had a number of water-damaged ceiling tiles that can indicate leaks from either the roof or plumbing system. The media center/library was converted from a gymnasium during the 1989 renovations. Originally, this room had an open ceiling with three windows on the eastern wall. These windows were sealed and a suspended ceiling was installed above the window frames. The exterior of each window frame was also sealed, one with brick, the other with plywood (see Picture 10). Ceiling tiles around the edges of the plywood sealed window frames were water damaged. This condition indicates that rain/moisture is penetrating through the seams of the plywood plugs. In addition, fiberglass insulation was installed on top of the ceiling tiles. Fiberglass insulation and ceiling tiles can serve as growth media for mold, especially if wetted repeatedly. These materials should be replaced after a water leak is discovered and repaired.

Of note is the lack of roof gutters and downspouts on the sloped roof of the building complex. While water damage from rainwater around the building appears to be minimal, the exterior brick of the main building is coated with mud (see Picture 11), which indicates significant water exposure. The source appears to be rainwater runoff. Areas around the exterior of the 1989 wing have a layer of asphalt that extends from the base of the building for approximately two feet. Cracks between this asphalt layer and the exterior wall can result in water penetrating into the building over time.

Shrubbery in direct contact with the exterior wall brick was noted in several areas around the building (see Picture 12). Shrubbery can serve as a possible source of water impingement on the exterior curtain wall due to the location of plants and tree branches growing directly against the building. Plants retain water and in some cases can work their way into mortar and brickwork causing cracks and fissures, which may subsequently lead to water penetration and possible mold growth.

Several classrooms also had a number of plants located in/or around univent returns or air diffusers (see Pictures 13). Plant soil and drip pans can serve as a source of mold growth. A number of these plants did not have drip pans. The lack of drip pans can lead to water pooling and mold growth on windowsills when used indoors. Wooden sills can be potentially colonized by mold growth and serve as a source of mold odor. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

The carpet in classroom 137 appears to be stained from water penetration through an exterior door. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy carpeting is not recommended. Please note that the carpet cannot be readily removed due to the asbestos content of tile beneath the carpet. If carpet is removed, all relevant containment precautions to prevent the aerosolization of asbestos from the floor tiles must be taken.

Other Concerns

Open holes around utility pipes were noted in the floor decking of the 1989 wing (see Picture 14). Open pipes and utility holes can provide a means of egress for odors, fumes, dusts and vapors from the storage space into classrooms.

Also of note was the amount of materials stored inside classrooms (see Pictures 15 and 16). In classrooms throughout the school, items were seen piled on windowsills, tabletops, counters, bookcases and desks. The large amounts of items stored in classrooms provide a surface for dusts to accumulate. These items, (e.g. papers, folders, boxes, etc.) make it difficult for custodial staff to clean around these areas. Accumulated chalk dust was noted in several classrooms. Chalk dust is a fine particulate, which can become easily aerosolized. Household dust and chalk dust can be irritating to the eyes, nose and respiratory tract. These items should be relocated and/or cleaned periodically to avoid excessive dust build up.

Cleaning materials were observed in several areas throughout this building. Cleaning materials frequently contain ammonium compounds or sodium hypochlorite (bleach-products), which are alkaline materials. It was also reported that the custodial staff used ammonia to clean hallway floors in order to remove accumulated salt stains from student traffic. The use of disinfectants in this manner can expose an individual to ammonium compound vapors, which can lead to irritation of the eyes, nose or respiratory tract.

A chemical odor was noted in the art room and immediate hallway. It was reported that the art teacher had used a spray coating in an outdoor area near opened classroom windows, which were the most likely pathway for off-gassing vapors to enter the building. The spray coating material found in the art room contains acetone, which can be an eye and respiratory irritant.

Conclusions/Recommendations

Occupant symptoms and complaints are consistent with what might be expected in an environment with a poorly operating or non-existent ventilation system. The conditions noted at Granville Village School raise a number of complex issues. The combination of the building design, maintenance, work hygiene practices and the condition of stored materials in the building can have an adverse impact on indoor air quality. No exhaust ventilation exists in the 1934 building. Without exhaust ventilation, normally occurring indoor air pollutants can build up and linger in classrooms. The use of odorous or dust generating materials can also serve to exacerbate irritation of the eyes, nose and throat in sensitive individuals. For these reasons a two-phase approach is required, consisting of immediate **(short-term)** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address overall indoor air quality concerns.

1. Consider consulting a ventilation engineer to balance the school's ventilation system. Have the ventilation engineer examine each univent for function to ascertain if an adequate air supply exists for each room. Operate univents while classrooms are occupied. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.

2. Remove all obstructions from univents and mechanical exhaust vents to facilitate airflow. Ensure all exhaust ventilation flues are open and operational. Operate exhaust ventilation during occupancy. Examine exhaust motors for function. Increase exhaust if necessary.
3. Examine the feasibility of installing a hood/barrier to shield the kindergarten univent fresh air intake from northwest winds.
4. Repair the exhaust vent motor for the 1964 wing. Remove the bird's nest.
5. Consider reconfiguring the media center/library to remove bookshelves that straddle the univent. Examine the feasibility of moving the computer stations closer to the exhaust vent airstream.
6. Consider increasing the dust spot efficiency of univent filters. Note that increased filtration can reduce airflow produced through increased resistance. Prior to any increase of filtration, each piece of air-handling equipment should be evaluated by a ventilation engineer as to whether it can maintain function with more efficient filters.
7. Instruct room occupants to keep hallway doors closed to enhance exhaust ventilation in classrooms with ceiling mounted exhaust vents.
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, implementation of scrupulous cleaning practices, to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low, should be implemented. Among these methods can be the use of vacuum cleaning equipment outfitted with a high efficiency particulate arrestance filter (HEPA). Drinking water during the day can

help ease some symptoms associated with a dry environment (throat and sinus irritations).

9. Examine the seal of the media center/library window plugs for water tightness. Once water-tightness is reestablished, replace any remaining water-stained ceiling tiles. Remove water damaged fiberglass insulation. Examine the area above and behind these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
10. Reduce/trim or remove plants that are growing against the exterior brick curtain wall.
11. Move plants away from univents in classrooms. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
12. Remove water damaged carpet from classroom 137 and disinfect areas of floor underneath water-damaged carpeting with an appropriate antimicrobial. Repair door to render airtight with weather-stripping.
13. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
14. Clean chalkboards and trays regularly to prevent the build-up of excessive chalk dust.
15. Store art and cleaning products properly and keep out of reach of students.
16. Seal open holes around utility pipes to prevent odor and dust movement.

17. Have a chemical inventory done in all storage areas and classrooms. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Follow proper procedures for storing and securing hazardous materials. Obtain Material Safety Data Sheets (MSDS') for chemicals from manufacturers or suppliers.
18. Maintain these MSDS' and train individuals in the science department in the proper use, storage and protective measures for each material in a manner consistent with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (MGL, 1983).

The following **long-term measures** should be considered:

1. Install a gutter and drainage system.
2. Examine the feasibility of providing mechanical exhaust ventilation in the 1934 building. A former make-up air vent (see Picture 17) for the furnace exists in the northwest wall of the school. Consider the feasibility of installing below floor ducts in the 1934 building basement and using the old furnace make up air vent as the terminus for a mechanical exhaust vent. If this is done, ensure that the system design does not deliver exhaust air to the kindergarten fresh air intake vent.
3. Examine the feasibility of providing a fresh air supply for the art room.
4. Consider the feasibility of increasing fresh air delivery to the media center/library with an upgraded univent system, installation of ceiling fans or removal/restoration of the original ceiling system to increase the volume of the room.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

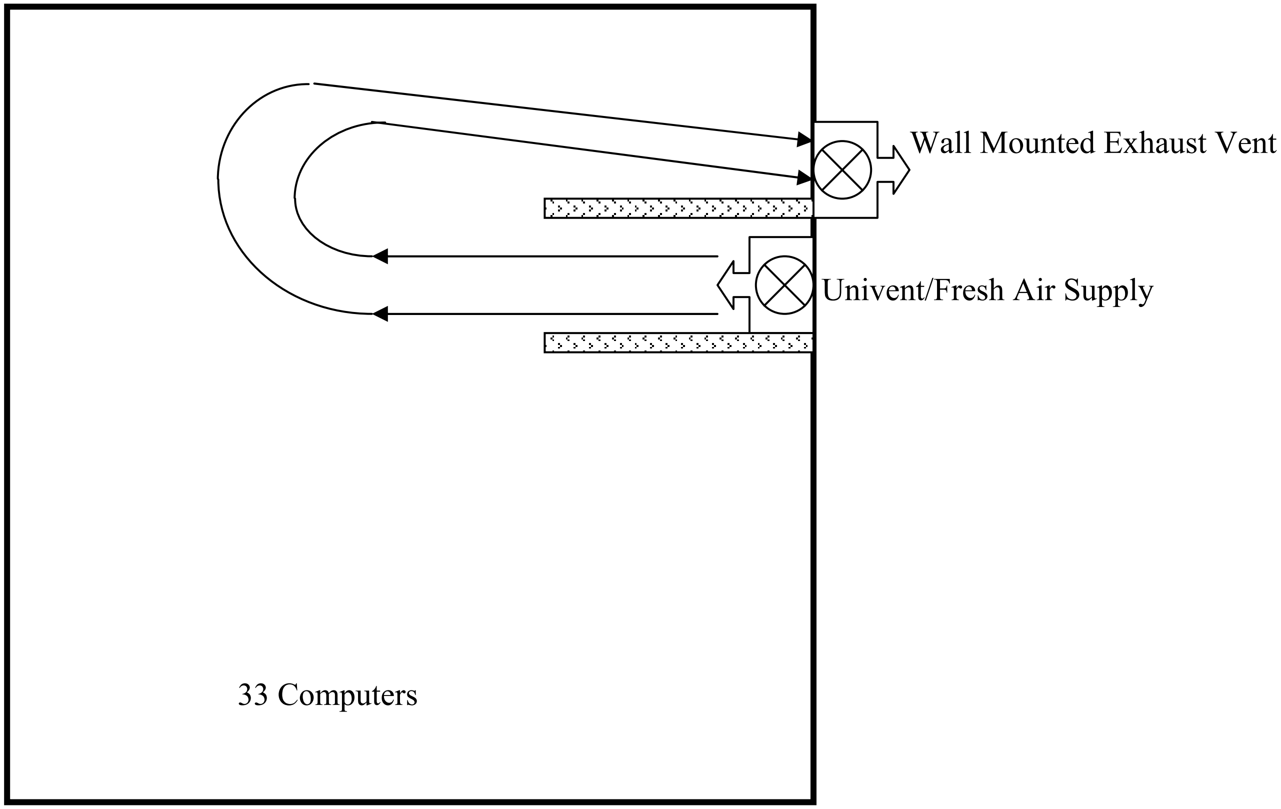
BOCA. 1993. The BOCA National Mechanical Code-1993. 8^{th} ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Figure 2 **Airflow in the Media Center Library**



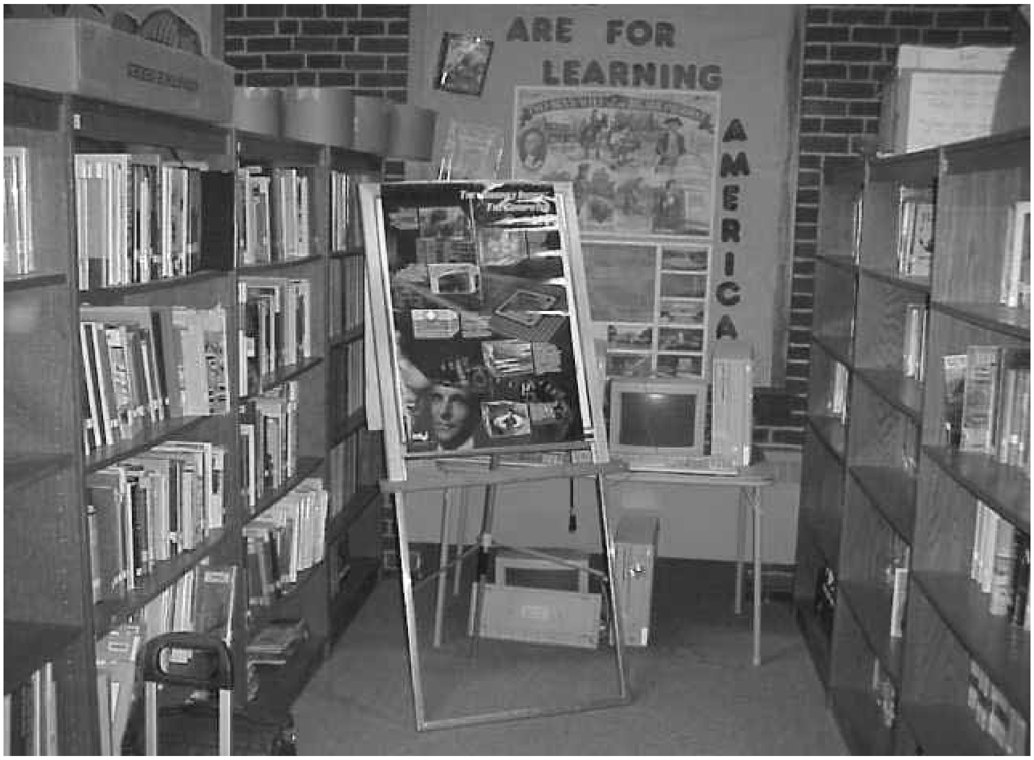
Key

Airflow from Ventilation System

Book Shelf

Drawing Not to Scale

Picture 1

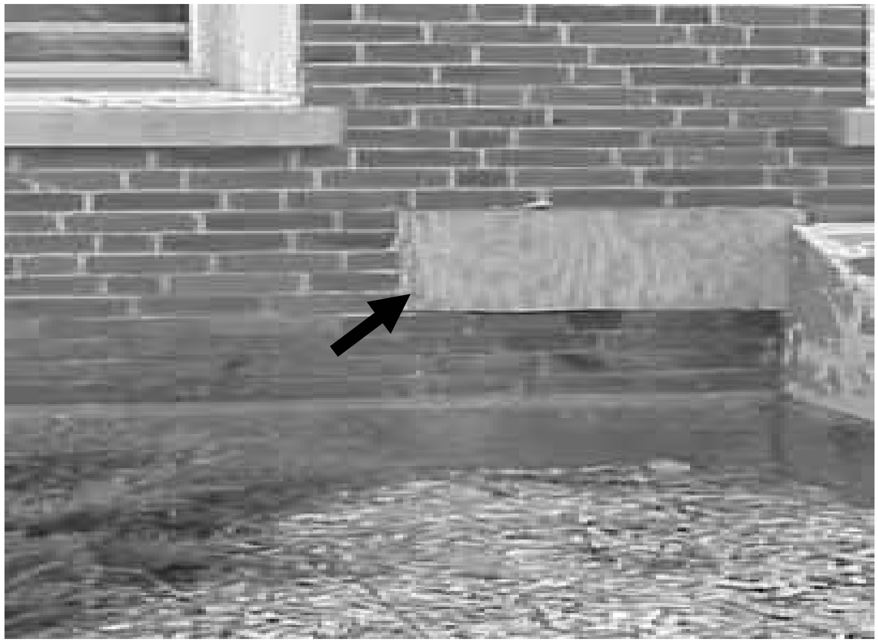


Univent Blocked With Poster Board

Picture 2

Air Diffuser Blocked With Paper, Return Vent Blocked with Paper Roll

Picture 3



Kindergarten Univent Fresh Air Vent Blocked With Plywood

Picture 4

Original Exhaust Vent In 1934 Building

Picture 5

Top Of Vent

Interior Of 1934 Building Exhaust Vent Sealed With Plywood

Picture 6

Exhaust Vent Cupola of 1934 Building

Picture 7

Exhaust Vent over Doorway

Picture 8

Bird's Nest Noted in Exhaust Vent Motor for 1964 Wing

Picture 9

Two Thermostats in the Same Room

Picture 10

Windows of Former Gymnasium, Note Plywood Sealing Window Frame

Picture 11

Exterior Brick and Asphalt Discoloration Indicating Water Contact

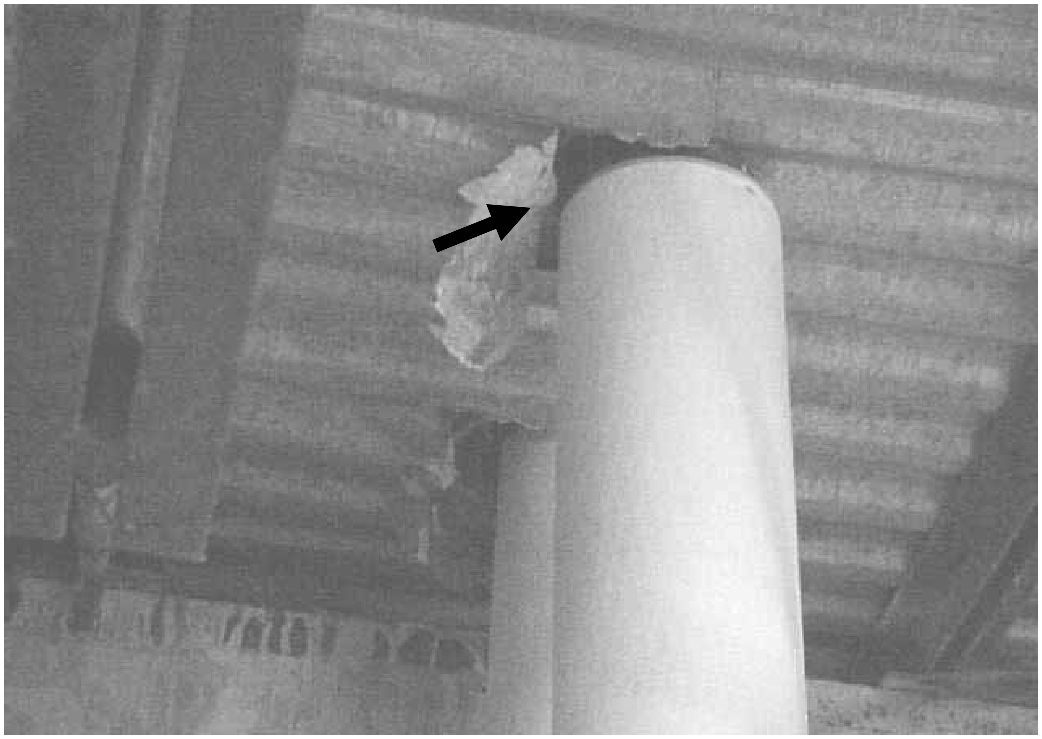
Picture 12

Shrubbery Impinging On Exterior Wall of Gymnasium

Picture 13

Plants Over Univent

Picture 14



Hole In Floor Decking Of 1989 Wing

Picture 15

Stored Classroom Material

Picture 16

Stored Materials Blocking Univents

Picture 17

Former Make-Up Air Vent for Boiler

TABLE 1

Indoor Air Test Results –Granville Village School, Granville, MA – March 31, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	406	54	21					
Room 141 Pre-Kindergarten	1009	73	18	8	yes	yes	no	univent off, 2 CT
Room 141 Kindergarten	1198	74	19	19	yes	yes	yes	univent off-blocked by shelf, exhaust blocked by boxes, 4 CT, door open
Library	911	74	17	16	no	yes	yes	univent and exhaust off, exhaust deactivated-turned on, 10+ CT, 1 missing ceiling tile, 33 computers
Art Room	710	73	15	19	yes	no	yes	exhaust off, window and door open, paint odor-spray gloss on balloons outdoors
Counselor	887	73	18	0	yes	yes	no	univent off, door open
Room 138	1320	72	20	41	yes	yes	yes	univent off, exhaust off-blocked by boxes/cabinets, door open (open to Room 137)
Room 137	1225	71	18	0	yes	yes	yes	univent and exhaust off, water damaged carpet near door, door open
Room 136	1109	71	18	10	yes	yes	yes	univent and exhaust off, plant on paper plate

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results –Granville Village School, Granville, MA – March 31, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Music Room	993	73	18	15	yes	yes	yes	3 CT
Science Room	958	73	16	17	yes	yes		plants over univent, wall crack, sinks-dry drains, ammonia cleaner, door open
Room 116	1032	74	16	17	yes	yes	yes	door open
Room 128	1255	75	22	15	yes	yes	yes	univent off-paper on univent, rubber cement, chalk dust, door open
Room 127	1191	75	19	13	yes	yes	yes	univent off-book on univent, chalk dust
Room 117	1141	74	17	19	yes	yes	yes	univent off-blocked by chair, 4 CT, chalk dust
Room 126	968	74	16	17	yes	yes	yes	chalk dust, door open
Room 125	867	74	17	17	yes	yes	yes	univent blocked by shelf, door open
Room 122	878	74	17	15	yes	yes	yes	boxes on univent, door open
Room 124	907	74	21	15	yes	yes	yes	univent off, door open, chalk dust

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results –Granville Village School, Granville, MA – March 31, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 123	960	74	15	16	yes	yes	yes	chalk dust, door open

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%